# FISH PASSAGE CENTER

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**MEMORANDUM**

TO: Tom Lorz, CRITFC
Derek Fryer, USACE
Charles Chamberlain, USACE
Eric Hockersmith, USACE

FROM: Michele DeHart, FPC

DATE: November 15, 2016

RE: Review of Paulsen and Fisher Draft entitled, "Bypass effects and smolt-to-adult survival: a re-analysis of CSS and transport study yearling chinook and steelhead smolts", dated July 1, 2016.

In response to your request the Fish Passage Center (FPC) staff has reviewed the subject draft report which was circulated for review through the US Army Corps of Engineers Study Review Work Group (SRWG). The SRWG distribution also specified November 25, 2016 as the due date for comments on the draft. Our overall conclusion is that the draft report in its present form does not make a compelling or convincing case for bypass selectivity and does not provide a plausible rationale for the delayed mortality and reduced SARs that occur for transported and bypassed salmon and steelhead, nor does the draft report raise any valid concerns regarding the Comparative Survival Study analytical results and the management application of those results. The CSS data and analyses simply report what is actually happening as the result of present FCRPS configurations and operations. The draft report is fraught with contradictions and conflicting findings. The following is a list of our review comments for your consideration.

- The draft report proposes that smaller fish are more likely to enter the FCRPS juvenile bypass and collection systems. If the analysis was scientifically robust, bypass/collection system selectivity for smaller fish would add to the significant body of scientific analyses supporting maximization of spill for fish passage at hydroelectric projects. The FPC staff reviewed fish length data which indicate that overall, wild fish are smaller than hatchery fish. **If bypass selectivity actually occurs, this leads to the conclusion that juvenile bypass/collection systems at FCRPS projects have a disproportionally larger adverse impact on wild stocks of salmon and steelhead than on larger hatchery produced fish.**

- The use of length at marking as the primary dependent variable is seriously flawed. The relationship between size at marking and size at bypass/collection encounter has not been established. Length at marking is not a reliable indicator of length at the time of encounter at juvenile bypass/collection systems.
- The FCRPS juvenile bypass collection systems are essentially dewatering systems, separating fish from water through a system of screens and mechanical devices and turbulent hydraulics. Considering a fishes experience through the juvenile bypass system, proposing that reduced SARs and delayed mortality observed in bypassed fish is due to smaller fish size is improbable and akin to "blaming the victim".
- The authors cite Zabel et al (2005) and Hostetter et al (2015) to support their hypothesis but do not cite the existing body of work that indicates that size selectivity does not occur at juvenile bypass collection systems. The authors do not recognize the serious limitations of these analyses. The authors do not provide any biological data or rationale that identifies the biological significance of minor fork length differences. Zabel et al (2005) did not find a consistent relationship between fork length and survival.
- Analyses of wild chinook mark groups from mainstem traps indicated no evidence of size selectivity at Lower Granite or Little Goose, and marginal size selectivity at Lower Monumental which is unlikely to have biological significance.
- Both this study (Paulsen and Fisher, 2016) and previous studies of bypass selectivity (Zabel et al., 2005 and Hostetter et al., 2015) ignore the most important variables affecting detection probability by failing to consider the documented effect of flow and spill on fish passage through powerhouse collection/bypass systems. Furthermore, these authors do not discuss the effect of flow on survival of fish to Lower Granite Dam.
- The Paulsen et al. Draft Report is fraught with contradictions and conflicting findings

## Bypass Selectivity Infers a Disproportionate Adverse Impact on Wild Fish

In cooperation with the CSS, the Smolt Monitoring Program (SMP) has been tagging wild and hatchery spring/summer Chinook and steelhead juvenile out-migrants at three mainstem traps: the Snake River Trap (at Lewiston, ID), the Grande Ronde River Trap (about 2 km from the confluence with the Snake River), and the Salmon River Trap (near Whitebird, ID). Comparison of lengths of wild and hatchery spring/summer Chinook and steelhead that were collected and tagged at each of these three traps between 2009 and 2016 revealed that wild fish are significantly smaller than hatchery fish (Figure 1 and 2) ($p<0.0001$ in all T-tests conducted). - Among these three traps, the mean lengths of wild spring/summer Chinook were 14.4-29.6 mm less than hatchery spring/summer Chinook and mean lengths for wild steelhead were 34.6-50.7 mm less than hatchery steelhead. Given this, if bypass selectivity actually occurs as hypothesized by Paulsen and Fisher (2016), one could only conclude that juvenile bypass/collection systems at FCRPS projects would have a disproportionally larger adverse impact on wild stocks of salmon and steelhead than on larger hatchery produced fish.

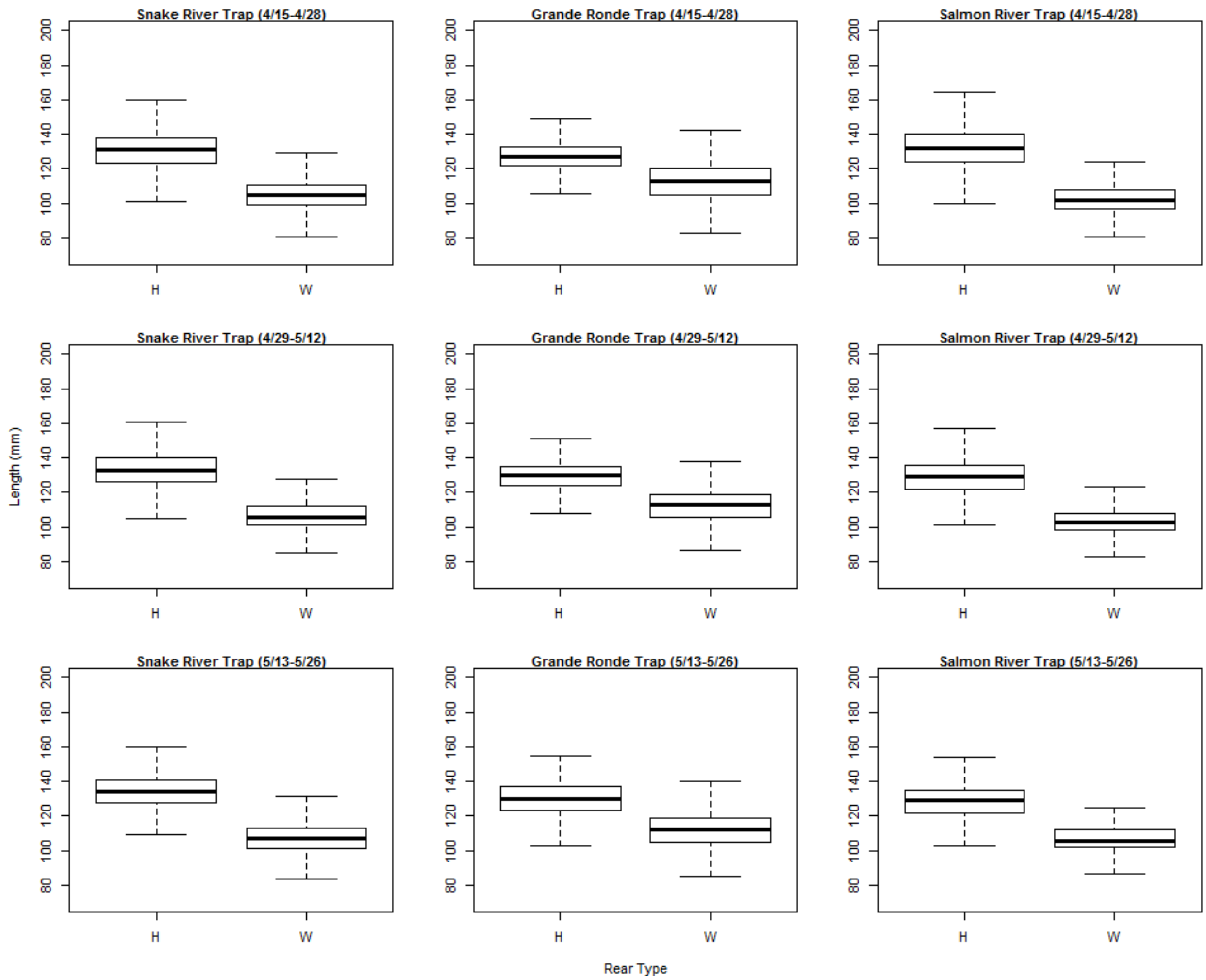


**Figure 1.** Box plots of juvenile hatchery (H) versus wild (W) spring/summer Chinook collected and tagged at the Snake River Trap, Grande Ronde River Trap, and Salmon River Trap between 2009 and 2016. To accommodate for seasonal changes in size, tagged fish were broken into three two-week blocks (Apr. 15-Apr 28, Apr. 29-May12, and May 13-May 26) for comparisons.

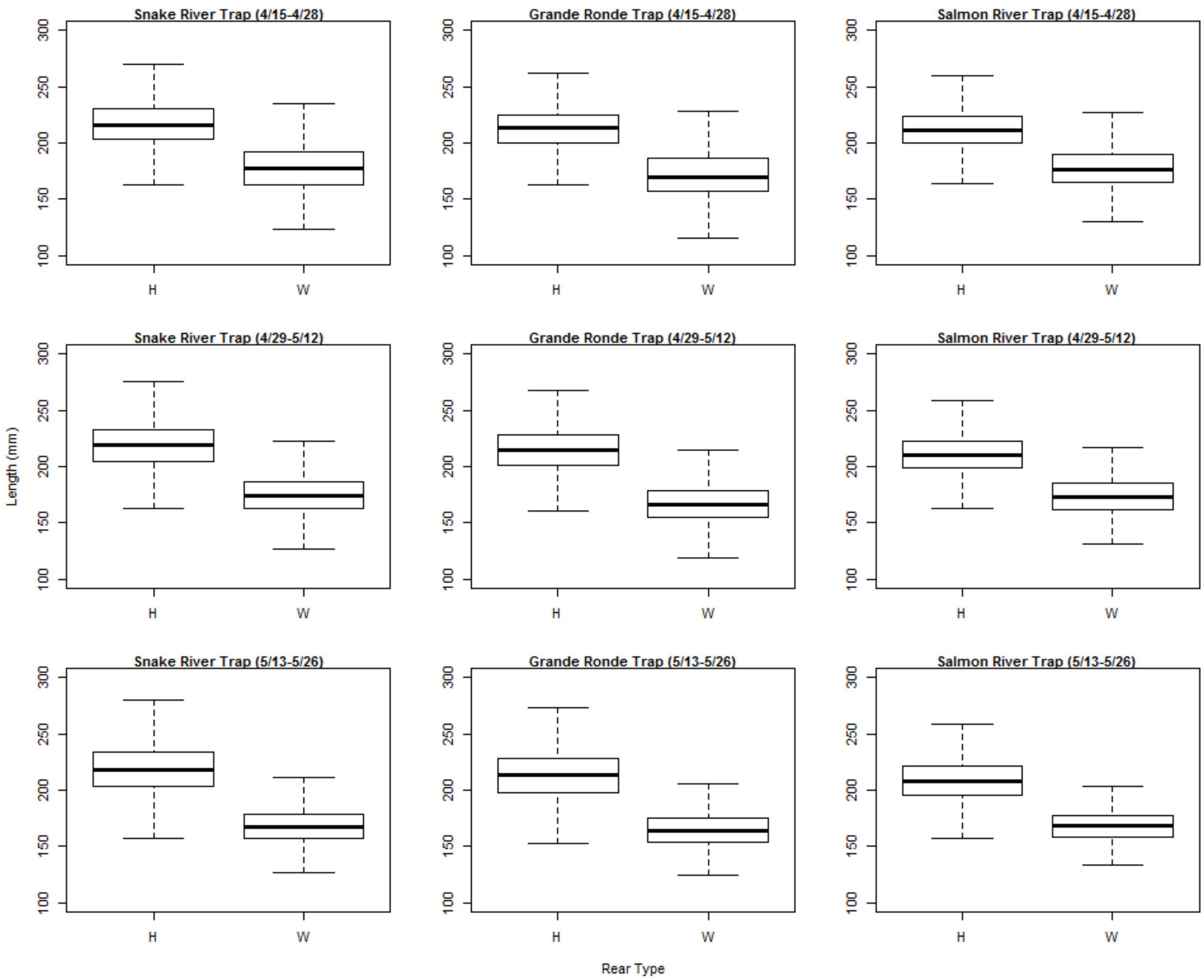


**Figure 2.** Box plots of juvenile hatchery (H) versus wild (W) steelhead collected and tagged at the Snake River Trap, Grande Ronde River Trap, and Salmon River Trap between 2009 and 2016. To accommodate for seasonal changes in size, tagged fish were broken into three two-week blocks (Apr. 15-Apr 28, Apr. 29-May12, and May 13-May 26) for comparisons.

## Length at Marking is Not a Reliable Indicator of Length at Bypass/Collection

PIT tag marking of salmon and steelhead occurs many months in advance of the downstream migration. Time of marking of hatchery fish varies from November through March. In addition size at marking varies among hatcheries and among years. In addition survival to Lower Granite is affected by many variables such as flow conditions and hatchery rearing conditions as well as other variables. Fish length and mass has been shown to change as fish migrate downstream (Congelton 2005). Fish travel time and survival is affected by flow conditions and distance to the first bypass/collection site. These environmental factors could result in changing size distributions from the time of marking to detection in bypass collection systems.

The use of length at marking as a surrogate for length at dam passage is problematic particularly when the tails of the distribution provide the greatest contrast as in Paulson (see Figure 16 in the Paulson analysis). We compared length at marking at CSS hatcheries with length at recapture at downstream traps during active migration. We found the correlation between length at tagging and recapture length was 0.74. This alone would suggest that there could be problems interpreting the results. However, when we plotted the length at tagging versus recapture length we found that the smaller the fish, the poorer that length at tagging fit the length at recapture when fish were actively migrating. This is particularly troubling when analysis by Paulson emphasized the impacts to the smallest fish in the population which are the fish for which the length at marking most poorly represents the length of the fish when they arrive at the dams.

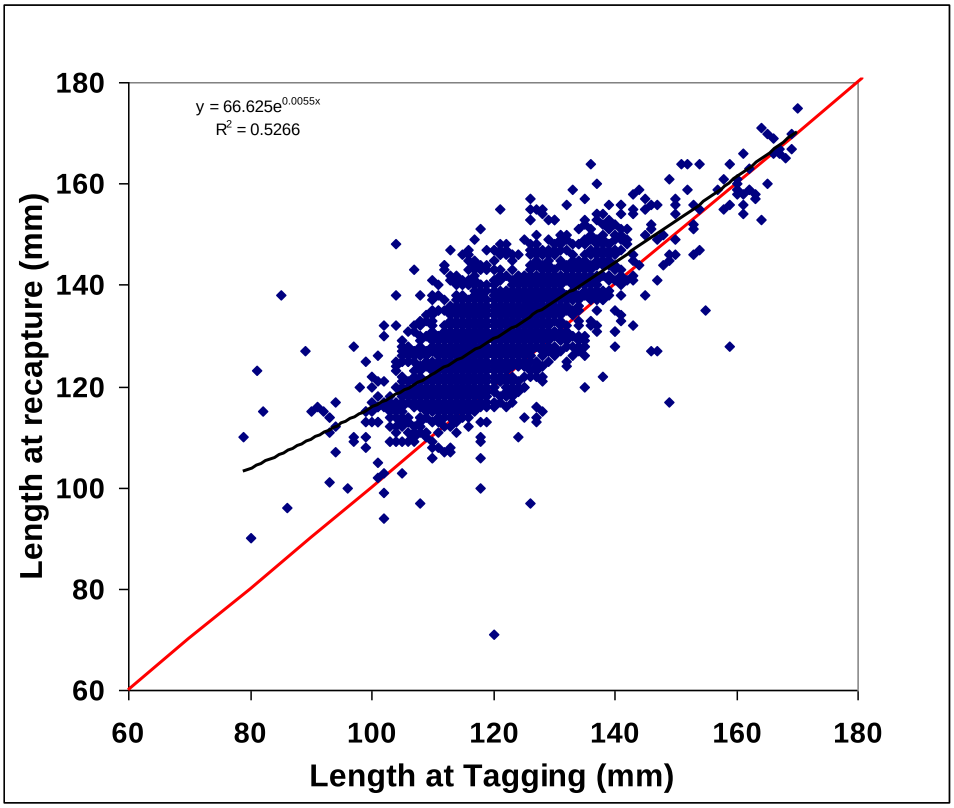


**Figure 3. Length at tagging versus length at recapture for CSS hatchery yearling Chinook PIT-tagged fish, tagged at Dworshak, Rapid River, Looking Glass and McCall hatcheries in the years 1995 to 2016. Recapture lengths were taken during down-stream migration at SMP traps on the Clearwater, Salmon and Snake rivers. The figure shows a 1:1 line in red, and a trend line shows how lengths at recapture differ from lengths at tagging.**

There appears to be a systematic bias in the data, with smaller lengths at tagging being less representative then lengths in larger fish. This is likely due to the fact that smaller fish are likely tagged earlier than larger fish and so spend a longer time rearing in the hatchery prior to release. An analysis like Paulson et al that uses these data is likely to have bias in their results related to this biased length indicator variable.

## Bypass Collection Systems are Essentially Dewatering Systems, Separating Fish from Water

In order to weigh the premise that lower powerhouse passage SARs are the result of fish size or condition, rather than the powerhouse passage experience its-self, the actual mechanism of the powerhouse passage and collection system must be understood. The function of a powerhouse juvenile collection/bypass system is to continually move fish through smaller and smaller volumes amounts of water as they make their way through the project (i.e., dewatering)..

To illustrate this, we use the dewatering system at McNary Dam as an example of the typical experience of fish passing through the bypassed system. At McNary, a turbine operating at the upper end of 1% of peak efficiency (at 75 feet of head) discharges approximately 12,350 cfs. A group of fish entering the project in this flow would be guided up the Extended Length Submersible Bar Screens (ESBS) into the gatewell, up the gatewell by the Vertical Barrier Screens (VBS), and discharged into the collection channel via three orifices (each discharging 14.3–16.7 cfs, under normal conditions). Upon initially entering the Juvenile Bypass at McNary, fish are separated from an average unit flow of 12,350 cfs into a 14.3–16.7 cfs orifice flow (three orifices per unit) which is routed into the juvenile collection channel. Only 0.4% of the original unit flow discharges through the orifices into the collection channel, which equates to a 99.6% reduction in flow. According to the Operations and Maintenance Manual at McNary, total flow in the collection channel can range from a minimum of 406 cfs to a maximum of 728 cfs. Under normal operating conditions, flow through the juvenile collection channel at McNary typically ranges between 600 and 700 cfs, depending on forebay elevation (with one orifice per gatewell open) (Carl Dugger, USACE, personal communication). At the downstream end of the collection channel there is a dewatering structure comprised of floor and side screens that separates the fish from a flow of 600–700 cfs in the collection channel to a flow of 30 cfs in the transportation flume. Therefore, approximately 95% of the collection channel water is removed before fish enter the transportation flume. Prior to the transportation flume, all fish moving through the juvenile bypass at McNary experience ESBS, VBS, gatewells, orifices, the collection channel, and the dewatering screens at the downstream end of the collection channel. As fish travel through the transportation flume, flows continue at 30 cfs through a set of four PIT-tag detectors after which the transportation pipe either routes fish directly to the river (Primary Bypass) or through the sampling facilities (Secondary Bypass)..

Considering the extensive dewatering mechanisms, hydraulics, potential for injury and disorientation that are likely to result in vulnerability to tailrace predation, it is difficult to accept the notion that the cause of the documented lower SARs for the powerhouse route of passage is fish size selectivity. Equating lower bypass SARs to fish size is analogous to "blaming the victim". It is not plausible that these systems are not directly responsible for lower SARs associated with the powerhouse passage route.

## Paulsen and Fisher Ignore the Body of Scientific Work that Concludes that Bypass Selectivity Does not Occur

**Buchanan et al. (2011):** This study analyzed PIT-tag data to identify the history of bypass system use by individual juvenile fish and compared the observed numbers of adults that returned with specific juvenile passage histories to the numbers of adults expected in the absence of any bypass effects. The authors found strong evidence that bypass events are associated with reduced adult return rates of Chinook salmon and steelhead smolts. In general, fish that migrated through the hydrosystem without detection in any bypass system had higher adult return rates. The authors found no consistent evidence that bypass systems were size selective for smaller fish. The authors also observed that the long lag time between fish being PIT-tagged at hatchery locations and subsequent detection events is problematic in attempting to assess bypass/collection size selectivity using these data.

**Berggren et al. (2006):** Based on the results of Zabel et al. (2005) and on NOAA's comments on the 2005 CSS Annual Report the CSS Oversight Committee included an analysis of bypass selectivity in its 2006 Annual Report (Chapter 9 of Berggren et al. (2006). The analysis focused on wild Chinook salmon, because this group exhibits the largest transport vs. in-river post-Bonneville differential delayed mortality difference. Using an AIC-based model-selection procedure, the level of empirical support for size–detection probability relationships at LGR, LGS, and LMN was evaluated using smolts tagged and released immediately upstream of Lower Granite pool as part of the CSS during migration years 1998-2006. Size–detection probability function parameters (i.e., the slope and intercept of fitted logistic functions) and their associated uncertainty for LGR, LGS, and LMN bypass/collection sites were estimated. Fork length at release between detected and undetected smolts, minus known removals made at upstream projects, through year and project-specific t-tests were compared. This analysis suggested that on average, size–detection probability relationships are likely of negligible importance for wild Chinook salmon study group comparisons currently made as part of the CSS.

**Hostetter et al .(2015)**. Paulsen and Fisher (2016) rely on Hostetter et al. (2015) to support their conclusion that bypass/collection size selectivity occurs, however they ignore serious technical limitations of the Hostetter et al. (2015) analysis. A Fish Passage Center technical review completed on February 16, 2016, has been available to the public and was distributed to the region's Fish and Wildlife Management agencies and tribes. The FPC found that, due to the significant methodological and analytical problems in this work, the findings do not have management application. The study and resulting conclusions are based on one year of collected data representing a single set of environmental conditions. Only hatchery fish were marked and evaluated for this study. No data are presented to demonstrate that daily mark groups were of consistent size over the time period. Thus, length may be confounded with other variables not included in this analysis that changed over the time period. Inferences about trait selectivity on detection probability at Lower Granite Dam cannot be made from this study since all the fish utilized in this study were tagged at this location.

**Zabel et al. (2005):** Paulsen and Fisher (2016) also rely on Zabel et al. (2005) to support their conclusion of bypass/collection size selectivity. Zabel et al. (2005) presents an overview of capture/recapture models exploring the analytical potential to incorporate individual variability into population survival estimates. However, Zabel et al. (2005) does not include consideration of the effect of environmental variables such as flow and spill on detection probability. Although Zabel et al. (2005) discusses evidence of bypass selectivity, the actual differences in size and the biological significance of that difference are not discussed. In addition Zabel et al. (2005) concludes that there is not a consistent relationship between fish size and survival and that Cormack-Jolly-Seber population survival estimates are robust. Finally, Zabel et al. (2005)

concludes that studies that include marking fish that are collected at dams (such as Hostetter et al.) have the potential of not representing the overall migrating population.

**Paulsen and Fisher (2015) Do Not Consider the Effect of Environmental Variables Such as Flow and Spill on Detection Probability.**

Paulsen and Fisher (2016), like Zabel et al. (2005) and Hostetter et al. (2015) do not consider the effect of environmental variables such as flow and spill on detection probability. This is the most critical factor affecting detection probability. The 2015 CSS Annual Report (McCann et al. 2015, Appendix J) illustrates the significant effect of flow and spill on detection probabilities at FCRPS projects. In historic non-spill years, all fish, meaning the entire size distribution were routed through powerhouse passage routes. Analyses that concluded that delayed mortality was occurring to transported and bypassed fish were based upon years of lower spill and higher proportion of powerhouse passage.

**Analyses of Wild Chinook Mark Groups Indicated No Evidence of Size Selectivity at Lower Granite or Little Goose, and Marginal Size Selectivity at Lower Monumental, Which is Unlikely to Have Biological Significance.**

For this review, we conducted an analysis to further investigate whether there is evidence of bypass selectivity at LGR, LGS, or LMN by comparing frequency distributions of wild spring/summer Chinook tagged at the Snake River Trap (at Lewiston, ID) to those that were detected at LGR, LGS, or LMN. If there was bypass selectivity, we would expect to see distributions of shorter length at LGR, LGS and LMN, compared to the Snake River Trap. The Snake River Trap is located approximately 52 kilometers above Lower Granite Dam and collects and PIT-tags active migrants from March through May. Using two-sample Kolmogorov-Smirnov tests (Sokal and Rohlf, 1981) we compared frequency distributions of wild spring/summer Chinook tagged at the Snake River Trap to those that were detected at LGR, LGS, or LMN. These tests indicated that there was no statistical difference in the length frequency distributions of the tagged population versus those fish that were detected at LGR or LGS, but that there was a statistically significant difference between the tagged populations versus those fish that were detected at LMN (Table 1, Figures 3-5). However, this statistically significant difference in length distributions is unlikely to be of biological significance. For example, the magnitude of the difference in mean lengths between the tagged population and the fish detected at LMN was only 0.6 mm, which is less than the measurement error for this metric.

**Table 1.** Summary statistics and results of Kolomogorov-Smirnov Test to test for differences in length frequency distributions between wild spring/summer Chinook tagged at the Snake River Trap between 2009 and 2016 and those same fish that were detected at LGR, LGS, or LMN. Bold italics indicate a statistically significant difference in length distribution of detected fish compared to the tagged population (α = 0.05).

| Group | Sample Size | Mean Length | Kolomogorov-Smirnov Test | |
|---|---|---|---|---|
| | | | D | p-value |
| Tagged at SNKTRP | 17,491 | 105.6 | | |
| Detected at LGR | 6,698 | 105.4 | 0.0167 | 0.1356 |
| Detected at LGS | 6,408 | 105.4 | 0.0143 | 0.2944 |
| Detected at LMN | 3,852 | 105.0 | 0.0399 | ***<0.001*** |

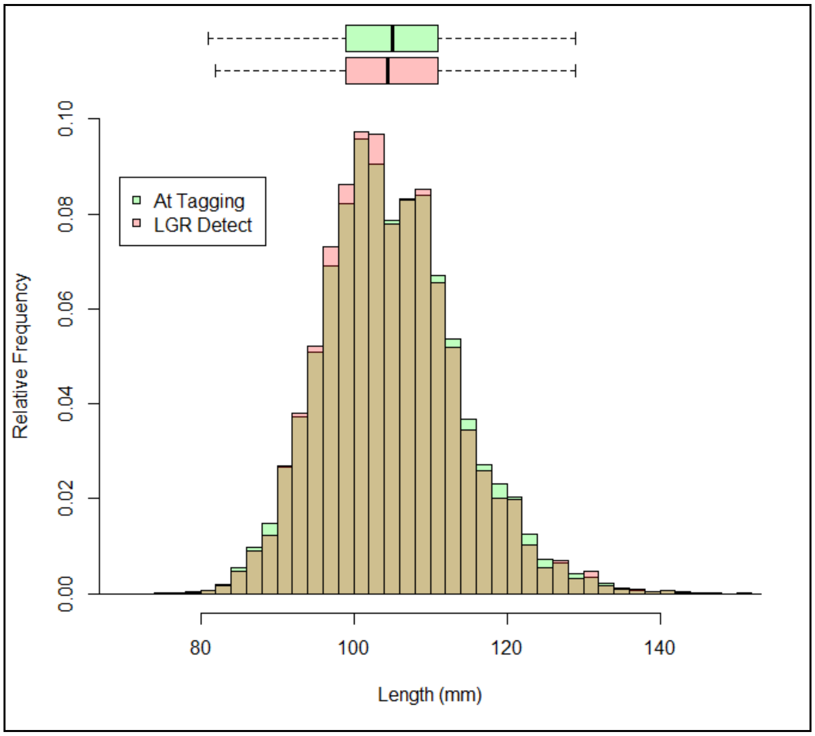


**Figure 3.** Length frequency distribution and box plot for wild spring/summer Chinook tagged at the Snake River Trap at time of tagging (At Tagging, green) compared to when the same fish were detected at Lower Granite Dam (LGR Detect, pink), 2009-2016.

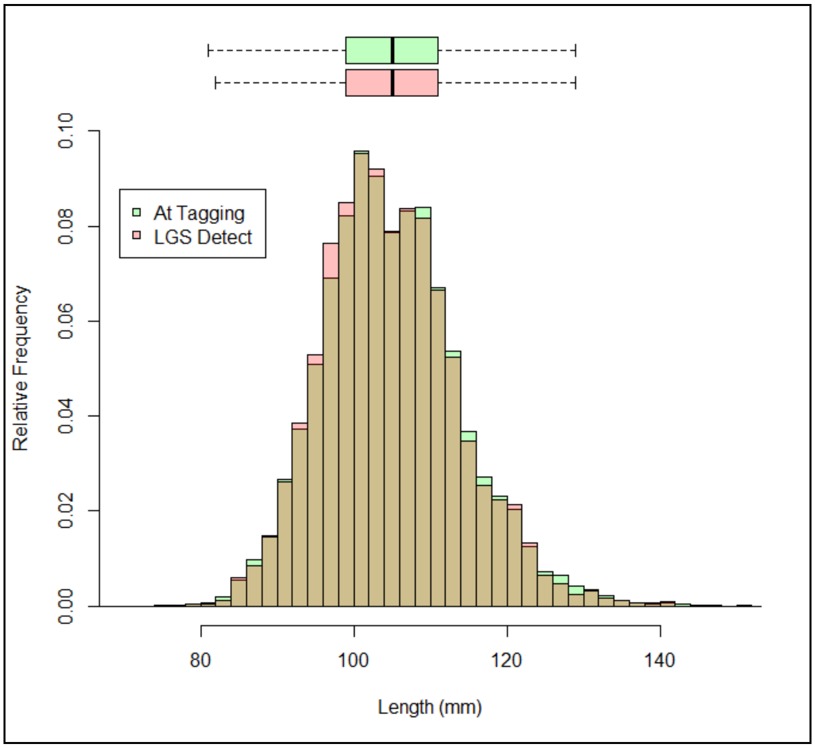

**Figure 4.** Length frequency distribution and box plot for wild spring/summer Chinook tagged at the Snake River Trap at time of tagging (At Tagging, green) compared to when the same fish were detected at Little Goose Dam (LGS Detect, pink), 2009-2016.

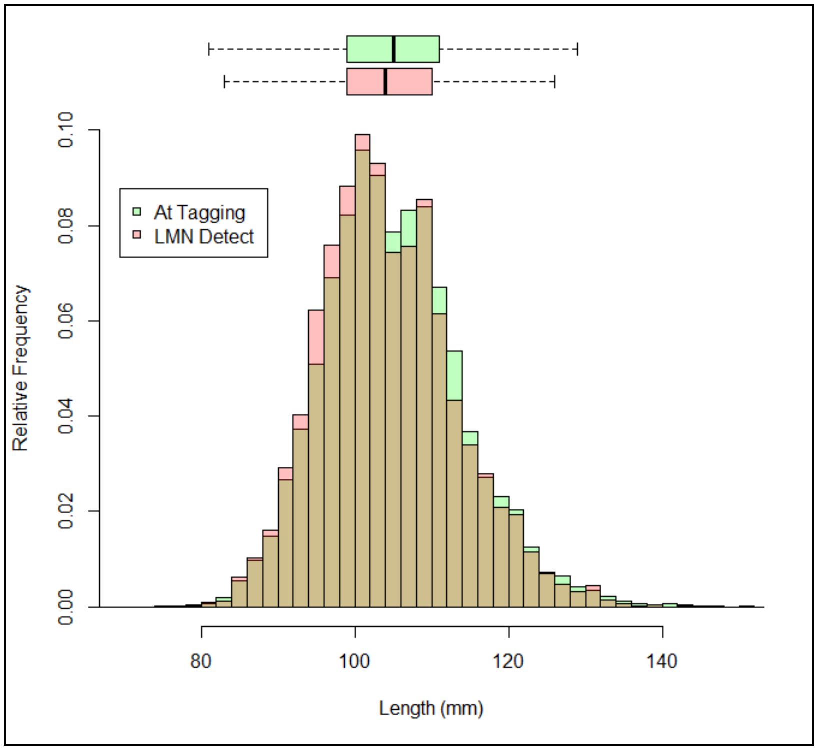


**Figure 5.** Length frequency distribution and box plot for wild spring/summer Chinook tagged at the Snake River Trap at time of tagging (At Tagging, green) compared to when the same fish were detected at Lower Monumental Dam (LMN Detect, pink), 2009-2016.

- **The Paulsen et al. Draft Report is Fraught with Contradictions and Conflicting Findings**

There are numerous contradictions and conflicting findings throughout the draft report. For example, the introduction claims that "after accounting for length at tagging, it appears that being bypassed has either modest or no significant association with survival from smolt to adult." However, results from the model that included length (Figure 10) indicated an even greater detrimental effect of bypass experiences on SARs than results from the model that ignored length (Figure 8). In addition, Paulsen and Fisher report that the effects of bypass experiences for the model that included length are "significant at 1%." Similarly, in one paragraph of the results section Paulsen and Fisher state that there is "no significant relationship between Snake bypass and SAR for CSS-tagged hatchery Chinook," but in the following paragraph they state that "fish bypassed more often are predicted to have lower SARs." These contradictory and conflicting findings raise serious concerns about the validity and reliability of the study's results and conclusions. . When all of the available data and analyses are considered, it is clear that powerhouse passage results in delayed mortality and lower smolt to adult return rate. It is clear that fish that pass through powerhouses, even larger fish have lower smolt-to-adult return rates and fish of all sizes will benefit from avoiding powerhouse passage. The effect of powerhouse passage on adult return has been well established. The available data and analyses does not support the further pursuit of individual fish characteristics as the causative effect of  delayed mortality associated with powerhouse passage, particularly when the actual physical structure and operation of these systems are considered.   Based on this analyses and available data, pursuit of this line of investigation is unwarranted and unlikely to generate useful results.

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